17035

Unmanned Vehicle Update

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TARDEC – Warren, MI

Intelligent Vehicle Technology Transition Conference

13 April 2007

SUPERIOR **TECHNOLOGY**

FOR A

SUPERIOR **ARMY**

TARDEC
U.S. ARMY TANK AUTOMOTIVE RESEARCH, DEVELOPMENT AND ENGINEERING CENTER

RDECOM

TACOM
The Soldier and Ground Systems Life Cycle Management Command

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Joint Center for UGVs (JC-UGV)
Mission and Focus

University Outreach

Partner with universities to establish robotics curriculums and build expertise in military ground robotics to meet customer needs

Industry Partnering

Partnering with consortiums and national industrial base to develop and transition cutting-edge unmanned vehicle technologies to the Warfighter

Congressional Language

The budget request included $110.0 million in PE 63005A, for combat vehicle and automotive advanced technology. Under this account, the Army pursues survivability and mobility, communications, energy and power, and ***autonomous technology improvements for manned and unmanned ground systems.*** The committee recommends an increase of $35.0 million in PE 63005A for acceleration of research in all of these areas, and $10.0 million for **unmanned ground vehicle prototype research to promote near-term transition of robotic ground vehicle technologies.**

Life Cycle Support

Partner with TACOM LCMC and RS JPO for total lifecycle decision and systems engineering support for the development and sustainment of robotics technologies

Government Research

TARDEC, the JC-UGV, RDECOM and OGA labs developing applied technologies to deliver the best possible solution to the Soldier

JC-UGV
R&D, Acquisition and Sustainment

Unmanned Systems Community

JC-UGV Collocation With the TACOM LCMC, RS JPO and TARDEC Fosters Technology Transfers Between Manned and Unmanned Systems

Manned Systems Community

Enabling Technologies

- Small UGV Prime Power
- UGV Armor and active protection
- Signature reduction
- Active suspensions
- Band track
- Power Mgmt
- Alternative power

Transfer

- Drivers' assistant
- Indirect vision driving
- Enhanced SA
- Auto NAV
- Tactical behaviors
- Reduced logistics
- Reduced human threat

Development

JC-UGV Coordination of TACOM/TARDEC Core Capabilities

Power and Energy — FY06 >$100M Manned
- Fuel Cells
- Pulse Power
- Hybrid Electric
- Intelligent Power Management
- Batteries

Survivability
- Signature Management
- Active Protection
- Lightweight Multi-Functional Armors
- Landmine Protection
- Laser Vision/sensor Protection

Mobility
- Engines
- Transmissions
- Suspension
- Tracks/Wheels
- Vehicle Structures

Intelligent Systems — FY 06 >$20M Unmanned
- Perception
- Tele-operation
- Autonomous Navigation & Intelligence
- Human-Robot Interaction and Control
- Actuator Kits

Partnering Opportunities to Deliver Technology to the Warfighter

University Outreach

- Establish robotics curriculums to build expertise in military robotics
- Fund long term and quick reaction technology development efforts focused on transitional solutions to material developers
- Foster individual efforts at local, state and national universities using various mechanisms

MICHIGAN

Robotics@GT Intelligent Machines

VirginiaTech Virginia Tech Autonomous Vehicle Team

Carnegie Mellon THE ROBOTICS INSTITUTE

Stanford AI Lab

Industry

- Maximize use of regional capabilities in automotive and defense based technologies.
- Exchange ideas and invest in technology development through existing CRADAs and contracts.

GM

Ford

DELPHI

EDS

Visteon

GENERAL DYNAMICS Strength On Your Side

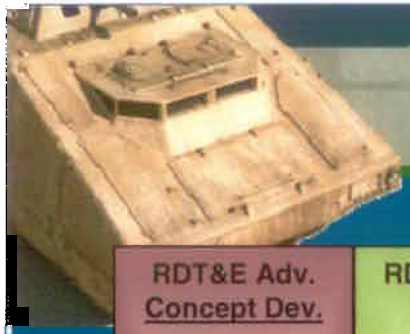
DaimlerChrysler

Small Business

- Utilize SBIR and STTR programs to allow small high-tech U.S. Businesses and academia the opportunity to provide innovative R&D solutions to critical DoD needs.
- Propose new SBIR topics and Invest in existing SBIR enhancements/plus-ups to companies developing unmanned ground vehicle technologies
  - **Intelligent Mobility**
  - **Innovative Control**
  - **Adaptive Payloads**
  - **Advanced Sensors**
  - **Intrinsic Mobility**

UNITED STATES ARMY SBIR STTR Programs

Forging relationships with leading national institutions



Life Cycle for Unmanned Ground Vehicle Technologies

RDT&E Adv. Concept Dev.

Academic

- Studies
- Research Grants

Industry

- SBIRS
- Prototyping

Government

- Task Analysis
- Prototyping
- Simulation
- Force Effectiveness Modeling

RDT&E Adv. Component Development Phase

Academic

- Modify National Robotics Initiatives, COTS Integration
- Curriculum Development

Industry

- Partnership with OEMs
- Production Analysis

Government

- Development of Intelligent Systems & Technologies
- "Unmanning" Manned Systems
- Technology Assessment and Transfer Management

RDT&E – System Development & Demo Phase

Academic

- Participation in Demos and Challenges
- Support Technology Insertion

Industry

- Analysis of Production Cost Reductions and Reliability

Government

- Supervision of Limited User Tests and IOT&E
- Safety Release Milestones
- Transfer of ILSC Requirements

Procurement & Deployment

Academic

- Contribute to COTS Training Plans

Industry

- Optimize Full Rate Production & Depots

Government

- New Equipment Training
- Post Production Product Improvement
- Support Field Modifications

Operations & Maintenance

Academic

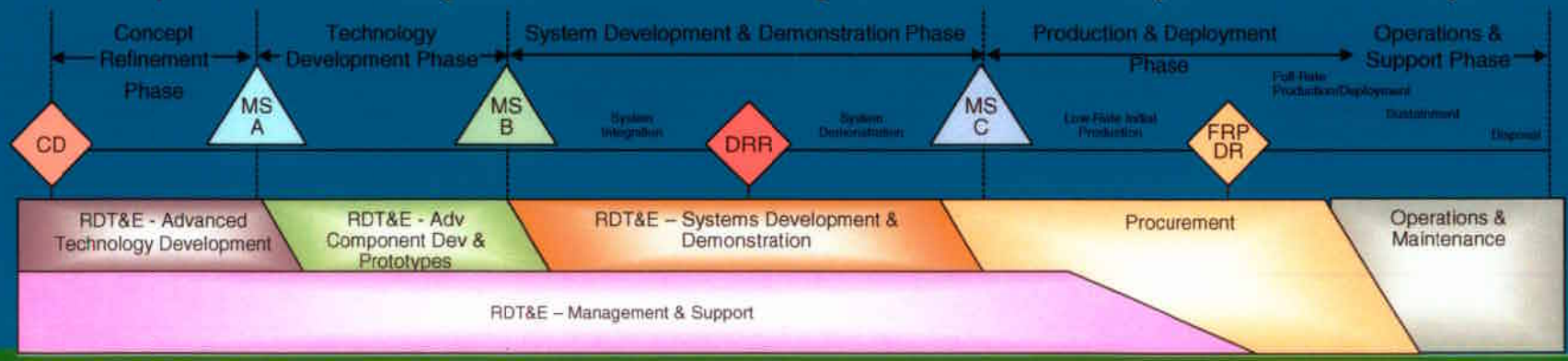
- Refine Curriculum to Improve Fielded Systems (Bots)

Industry

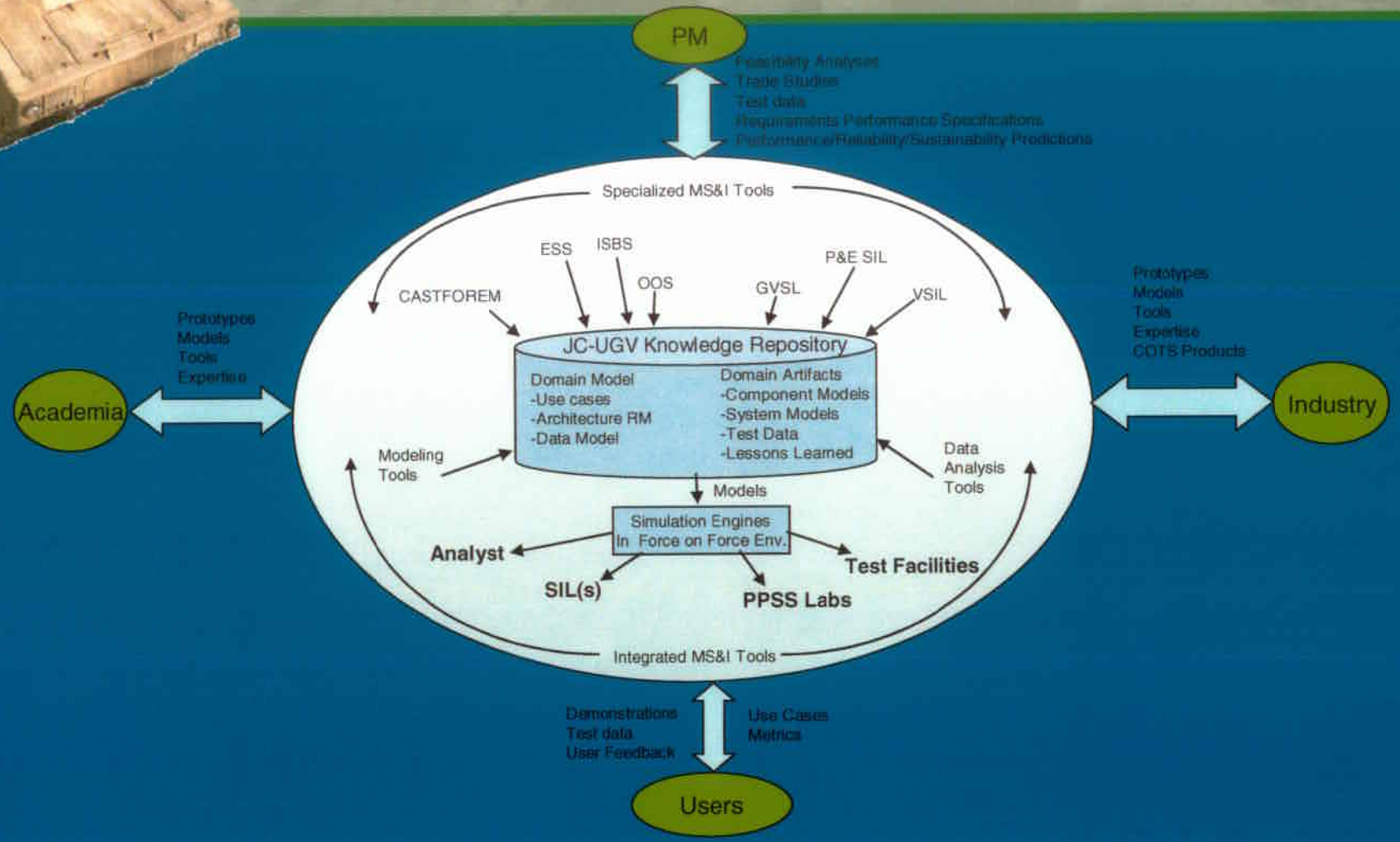
- Support Depot and Industrial base

Government

- Post Production Software Support
- Depot Maintenance Support
- Respond to Operational GAPS



JC-UGV Modeling, Simulation, and Integration Environment



An open, knowledge-centric environment integrates expertise from government, academia and industry to support PM and Users

Robotics Vehicle Technologies for FCS

TARDEC Stryker

MGV Crewmen

Crusher 1.0/2.0

Existing SW Source Code (color key)

- VTI*
- Crusher
- ANS

FCS WMI Surrogate

SOSCOE

FCS Defined Radio Network

SOSCOE

RSTA Surrogate

BCME Surrogate

BCME Surrogate

VMS Surrogate

PPS Surrogate

ANS

Acronyms:
VTI = Vetronics Technology Integration
WMI = Warfighter Machine Interface
BCME = Battle Command Mission Execution
PPS = Planning and Prep service
VMS = Vehicle & Management Service
RSTA = Reconnaissance Surveillance, & Target Acquisition
VMS = Vehicle Management Software
ANS = Autonomous Navigation System

Schedule

MILESTONE (FY)	07	08	09	10
ATO				
Integration of initial S&T and FCS components				
Integration of FCS ANS System onto Crusher Platform				
Upgrades to FCS Components				
Control Integration Experiments/Technical Readiness Review		△△ 6		
Non-ATO				
Mobility Testbed Design				
Mobility Testbed Fabrication				
S&T and FCS Component Integration on Mobility Testbed				
Mobility Integration Experiments/Technical Readiness Review			△△ 6	

Autonomous Platform Demonstrator (APD) Program

Existing DARPA/CMU-NREC Crusher 1.0

PM FCS
ARV SFR Requirements

Hybrid Drive Technology

Suspension Technology

Schedule & Cost

MILESTONES	FY07	FY08	FY09	FY10
Trade Study				
Concept Design and Integration				
Mobility Testing				
System Functional Testing				

Purpose:

- This platform demonstrator will develop, integrate, and test next generation UGV mobility technologies such as hybrid electric drive systems, advanced suspension systems, lightweight chassis technologies, and efficient, low density auxiliary systems integrated on a single platform while preserving deployability of 2 in a C-130.
- To design, integrate, and test (platform mobility/system performance) guided by and based on FCS ARV SFR requirements/specifications (including weight, mobility performance, and size).
- To develop an Autonomous Platform Demonstrator (APD) for the demonstration of ARV platform technologies developed under the ATO D.TAR.2008.04, Robotic Vehicle Technologies (RVT) for FCS ATO on an improved UGV platform.

Results:

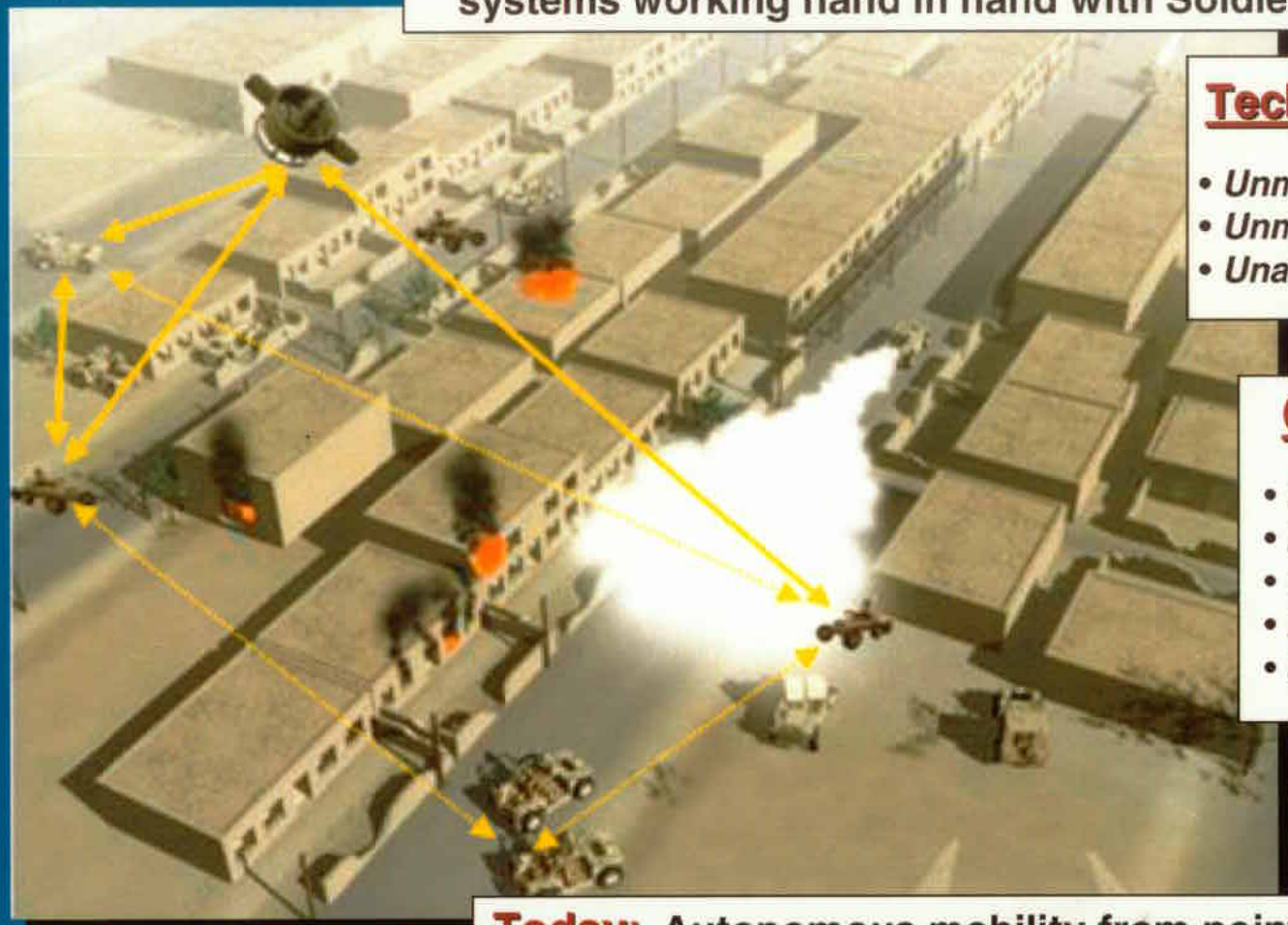
- Platform capable of demonstrating reliable mobility drivetrain and chassis subsystems (engine, transmission, suspension, and hybrid electric drive).
- Engineering data through platform mobility and performance testing to refine ARV SDD-level designs.

Payoff:

- Continuing to develop and mature UGV core mobility technologies into the APD will benefit all unmanned platform mobility, subsystem and control development.
- Higher performing UGV platform for continued ATO control experimentation.
- Integrated APD platform and experimentation data that provides design risk reduction for ARV platform rqmts.

Future Unmanned Systems

The Future: Fully networked near-autonomous systems working hand in hand with Soldiers



Technologies Covering

- *Unmanned Air Vehicles*
- *Unmanned Ground Vehicles*
- *Unattended Ground Sensors*

Core Technologies

- *Perception*
- *Intelligence*
- *Command & Control*
- *Platforms*
- *Safety*

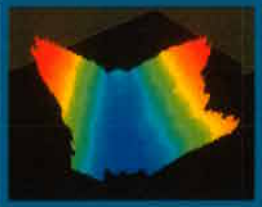
Today: Autonomous mobility from point A to Point B in static environments

Solving Tomorrow's Challenges Today

- Teleoperation
- Protection
- Safe Operations
- Bandwidth
- Power & Energy
- Planning
- Classification
- Affordability
- Latency
- Convoy
- Weaponization
- Behaviors
- Sensing
- OCU
- Mobility
- Resolution
- Interoperability
- Payloads

Army S&T Priorities for FCS Threshold Requirements

Intelligence/Tactical Behaviors



- Threat response/self security
- Tactical behaviors
- Formations/leader-follower

UGV Control for Overall System Effectiveness

- Warfighter machine interface
- Battle command integration
- Network constraints
- Weaponization

Safe Operations in Dynamic Environments

- Vehicle safety
- 360° Awareness

Platform Mobility Maturation

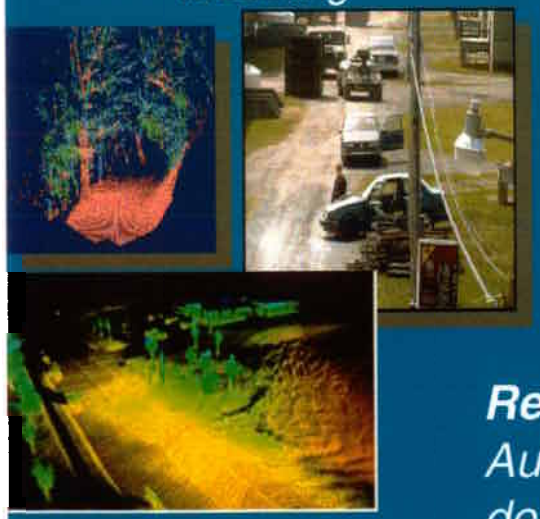
- SWaP Constraints
- Mobility enhancements
- Endurance

Intelligence/Tactical Behaviors

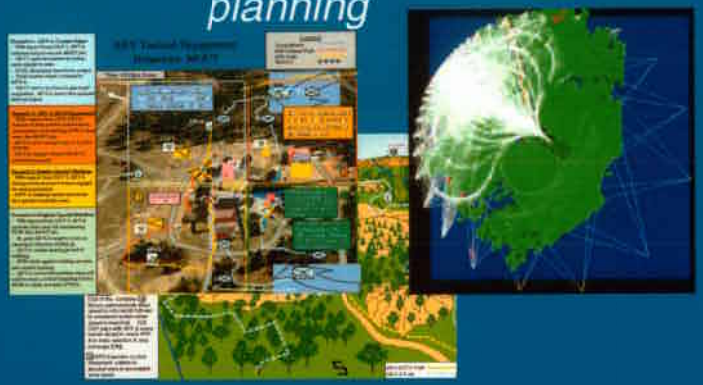
Current Performance

- *Point A to Point B autonomous navigation using a priori terrain info and local sensing for driving and situational awareness*
- *S&T progressing intelligent tactical behaviors in realistic scenarios*
  - *ARL Robotics Collaborative Technology Alliance*
  - *TARDEC/AMRDEC Robotic Collaboration ATO*
  - *TARDEC/ARL Near Autonomous Unmanned Systems ATO*

Perception and World Modeling



Deliberative and reactive planning



Layered detection and response

Required Performance

Autonomous, yet Soldier-like navigational decision making, threat detection and response, and collaborative behaviors to achieve a military objective

Formation control

Safe Operations in Dynamic Environments

Current Performance

- *Autonomous maneuver in complex terrain with stationary obstacles*
- *S&T progressing autonomous navigation in realistic scenarios*
  - *ARL Robotics Collaborative Technology Alliance*
  - *TARDEC Robotic Collaboration ATO*
  - *DARPA Urban Challenge*

Data collections with moving obstacles

Pedestrian Detection/Avoidance

Understanding dynamic environments for reactive planning

Required Performance

Autonomous maneuver in close proximity to pedestrians and vehicles to enable effective and safe Soldier robot teaming

Tactical Wheeled Vehicle Robotic Convoy

- Automate two 5 ton FMTV trucks to perform autonomous vehicle following
- Joint Project with PM CS/CSS
- Goal is low cost robotic convoy capability
- Supports manned driver automation for manned convoys
- On- and off- road operations
- Field Testing in November 06

NAUS Human Localization for Pedestrian Detection and Following

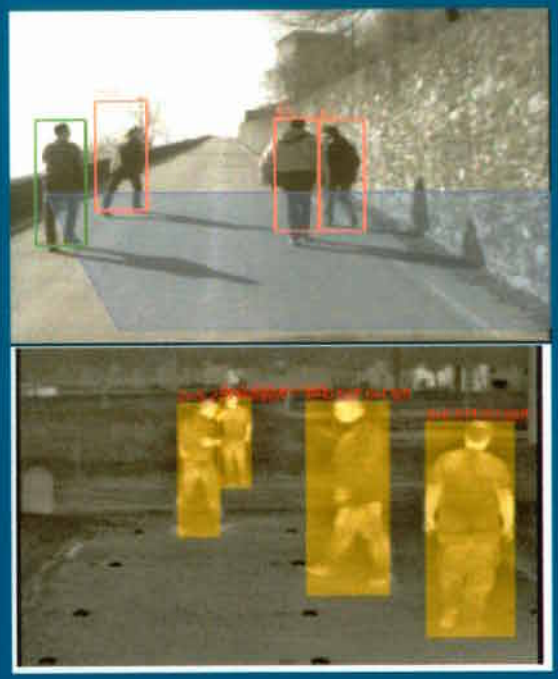
Pedestrian Detection: Use stereo IR and stereo gray scale to identify people in a single image pair.

Pedestrian Following: Use color stereo images to identify and track a person based on color and disparity.

Pedestrian Detection Algorithms

- Stereo Gray-Scale Pedestrian Detection
- Single frame detection
- Moving vehicle/person detection
- Frame rate ~22 fps

- Stereo Infrared Pedestrian Detection
- Single frame detection
- Moving vehicle/person detection
- Frame rate ~ 28 fps



Unmanned Systems Behavior

CORE BEHAVIORS

COMMUNICATE
- Transmit/receive digital data
- Transmit/receive voice

MOVE
- Move autonomously (individual)
- Move autonomously (formation)
- Move by teleoperation
- Move by remote control

SAFETY RELATED BEHAVIORS

SITUATIONAL AWARENESS
- Self awareness
- Terrain awareness
- Dismount awareness

SYSTEM SELF SECURITY
- Intent Analysis
- System Protection

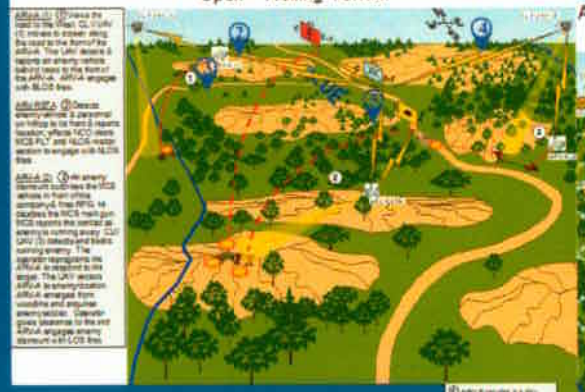
MISSION SPECIFIC BEHAVIORS

OBSERVE
- Occupy a vehicle position
- Conduct surveillance
- Conduct target acquisition

DEPLOY PAYLOAD
- Employ countermeasures
- Dispense sensors

ENGAGE TARGETS
- Designate a target
- Engage a target LOS
- Engage a target BLOS
- Engage a target with non-lethals

ARV Tactical Engagement Behaviors
Open – Rolling Terrain



ARV Tactical Movement Behaviors
Open – Rolling Terrain